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Original Research

Implementation Rule-Based System and Hamilton Method Based on Legal Provisions Governing Labor Union Representation

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ABSTRACT

Determining the representation of workers organizations in national tripartite bodies requires a fair and transparent calculation mechanism. Conventional data management has proven to be highly susceptible to duplicate worker identities and involves extremely time-consuming bureaucratic processes. This study aims to design and develop a web-based trade union membership tallying system using the Laravel framework. This system integrates a Rule-Based System algorithm to assess administrative eligibility in accordance with Ministry of Manpower and Transmigration Regulation No. KEP-201/MEN/2001 and the Hamilton Method algorithm to calculate proportional seat allocation. The methodology applied is software engineering through the Agile development model, which involves black-box testing and load testing on massive-scale population data. Test results demonstrate that the system is capable of executing multi-level validation and distributing remaining fractional seats without human subjectivity. The implementation of a security architecture using role-based access control successfully isolates the permissions of six user levels to prevent attempts to manipulate reporting data. The conclusion of this study confirms that automating the tabulation of the labor force using a combination of absolute rule logic and the largest remainder method can significantly improve accuracy, transparency, and fairness in industrial relations.

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1 INTRODUCTION

Harmonious industrial relations between employers and workers are a key pillar in maintaining national economic stability [1]. The involvement of workers organizations in national-level tripartite forums requires legitimate and proportionally measured representation to safeguard workers rights in the industrial sector [2]. The legitimacy of this representation is regulated by Minister of Manpower Decree No. KEP-201/MEN/2001, which establishes membership thresholds and procedures for calculating seat allocations [3]. To ensure the validity of these membership figures, the government also issued Minister of Manpower Regulation No. PER.06/MEN/IV/2005 as a standard operating procedure for conducting membership verification in the field [4]. The transition of these legal regulations to a digital ecosystem has become urgent to ensure legally binding administrative compliance [5].

The process of compiling data on national-level union members managed by government agencies currently faces very serious operational challenges due to the use of conventional recording methods. The tiered submission of

compilation documents from the regional to the central level using Excel is extremely time-consuming and prone to errors. A data collection system that relies solely on total numbers without detailed member identification creates a very high potential for data manipulation or duplication in order to meet minimum representation requirements. Weaknesses in this type of reporting infrastructure can have a devastating impact on the accuracy of information and undermine public trust in the final tabulation results [6]. Processing statistical membership data requires a reliable centralized system to prevent inconsistencies in reporting across regions [7]. An in-depth evaluation of the current tabulation methods is essential to identify operational weaknesses and formulate comprehensive solutions for improvement [8].

A review of the existing literature reveals a significant research gap in the field of decision support system development. The majority of previous studies still rely heavily on multi-criteria algorithms that involve subjective assessments and probability calculations [9]. These conventional methods are well-suited for flexible applications such as providing recommendations for commercial products [10]. A mathematical multi-criteria approach becomes entirely irrelevant when faced with government administrative needs that are strictly bound by positive state law [11]. The selection of academic majors based on objectivity has also demonstrated that rule-based approaches are far superior at minimizing evaluation bias compared to probabilistic computational methods [12]. The application of rule-based algorithms in the automated validation of document structures further reinforces the fact that mathematical logic is capable of providing a very high degree of consistency [13]. This study offers a novel approach through the design of a tabulation system architecture that integrates rule-based algorithms and the greatest remainder method. The application of a rule-based logic engine has proven to be highly precise in executing conditional instructions without the need for value negotiation [14]. The need for proportional treatment is addressed through the adoption of the Hamilton Method, which mitigates the dominance of the majority fraction in computational mathematical calculations [15]. This hybrid mechanism ensures that each worker organization is fairly evaluated for eligibility and that its share is calculated equitably [16], while also adhering to the axiomatic principles of ideal quota distribution [17]. This digital ecosystem is reinforced by the Laravel 12 framework and access restrictions using role-based access control [18]. The separation of six types of user access rights ensures that the confidentiality and integrity of reports cannot be compromised by unauthorized parties [19].

This software engineering study addresses the problem of how to design and build a web-based architecture for a national-level labor union membership data compilation system using the Agile methodology [20]. This study also formulates an implementation mechanism for integrating the Rule-Based System algorithm and the Hamilton Method to translate each legal requirement into a computational system. The primary objective of this study is to establish an automated reporting system from the regional to the central level, making it more structured and free from data errors [21]. The ultimate goal of this software system design is to resolve bureaucratic administrative issues and the high potential for data manipulation in conventional verification processes, thereby creating a far more transparent and equitable industrial relations ecosystem for all parties [22].

2 RESEARCH METHODS

2.1 Research Design and Data Collection

This study employs a software engineering research approach focused on the design of a web-based system architecture. The selection of this research approach is based on the need to build a computing system capable of handling the verification and tabulation of data for members of a national workers organization by integrating the selection of legal rules with the calculation of the largest remaining proportion. The software engineering approach provides a highly structured framework, ranging from the requirements analysis phase to the system testing stage. Software engineering has proven to be crucial in creating a robust digital ecosystem that is adaptive to the dynamics of government bureaucracy [20]. The implementation of this research approach enables the transformation of labor laws into programming algorithms.

The case study for this research was conducted at a ministerial-level government agency responsible for labor issues. Information was collected to analyze the weaknesses of the data collection system using Excel, which has long been highly susceptible to duplicate entries and has required an extremely long time to complete. The document review also examined various historical archival documents and legal texts that serve as the operational foundation for the ministry to ensure that feature specifications align with applicable verification procedures. The results of this review of various regulatory texts include the formulation of legal logic and calculation formulas for the “largest remainder” method, which will be translated into software algorithm code.

2.2 Rule-Based System Algorithms and Hamilton Method

The application of an algorithm-based approach offers significant advantages in terms of transparency and certainty of computational results compared to other probabilistic mathematical models. The system evaluates an organizations eligibility based on Ministry of Manpower and Transmigration Regulation No. KEP-201/MEN/2001, which is represented in the form of a mathematical model. The variables used include:

- P_i for the number of provincial leadership bodies
- K_i for the number of regency/city leadership bodies
- S_i for the number of verified labor unions
- A_i for the number of verified members
- J for an indicator of the presence of a leadership body in the national capital

The established threshold parameters are: a provincial threshold of 8 regions, a regency/city threshold of 103 regions, a labor union threshold of 150 units, and a membership threshold of 50,000 workers [3]. The determination of a confederations eligibility is carried out using the following logical equation:

$$R_i = [(P_i \geq 8) \wedge (J = 1)] \vee [(K_i \geq 103) \wedge (J = 1)] \vee (S_i \geq 150) \vee (A_i \geq 50000) \tag{1}$$

Where:

$$R_i = \begin{cases} 1, & \text{if it satisfies at least one rule} \\ 0, & \text{otherwise} \end{cases} \tag{2}$$

This study also provides a second method that simplifies the criteria, in which the eligibility evaluation requires only a minimum membership threshold, using the formula:

$$R_i = (A_i \geq 50000) \tag{3}$$

Where:

$$R_i = \begin{cases} 1, & \text{if } A_i \geq 50000 \\ 0, & \text{if } A_i < 50000 \end{cases} \tag{4}$$

Then, all stages of seat allocation calculations continue to use a mechanism identical to that of the first method. The final stage of seat allocation uses a proportional allocation algorithm that distributes resources based on population ratios, known as the largest remainder method [15]. The first stage requires the calculation of the Fixed Divisor, obtained using the formula:

$$APT = \frac{A_T}{W} \tag{5}$$

Where APT is the fixed divisor, A_T is the total number of members from all eligible confederations, and W is the total number of available seats.
The initial number of seats is allocated to each organization using the floor function with the equation:

$$KA_i = \left\lfloor \frac{A_i}{APT} \right\rfloor \tag{6}$$

Where KA_i is the first seat, which yields a definite number of seats. Since the rounding process will always leave a decimal fraction, the remaining members from the first stage are calculated using the formula:

$$SA_i = A_i - (KA_i \times APT) \tag{7}$$

Where SA_i is the remaining members. This result is then used in the next stage [17].
The second phase of this algorithm focuses on distributing the remaining seats that were not allocated in the first phase. The system calculates the availability of remaining seats using the equation:

$$KS = W - \sum KA_i \tag{8}$$

Where KS is the number of remaining seats. The result is then redistributed. These remaining seats are distributed one by one to the organizations with the largest remaining membership values in order until all available seats are completely exhausted. The system determines the allocation of additional seats by calculating the final seat allocation using the equation:

$$KF_i = KA_i + KT_i \tag{9}$$

Where KF_i is the final seat and KT_i is the additional seat, which is the result of the algorithm [16]. This mathematical mechanism ensures that all labor organizations are treated fairly in the allocation of representative seats within industrial relations bodies.

2.3 Stages of Software Development

This series of research phases applies an Agile software engineering methodology framework that prioritizes iterative development cycles and responsiveness to change [23]. The first phase begins with a requirements planning process that involves identifying issues with manual reporting and formulating technical specifications for the digital platform based on applicable legal texts. The requirements variables from the ministry were mapped in detail to ensure that the database architecture could accommodate hundreds of thousands of rows of employee data. The database structure was also designed to separate master data from periodic data.
The next stage is the development process, in which all legal provisions are translated into program code using Laravel 12. The logic of the Rule-Based System algorithm is implemented to select confederations, while the Hamilton Method module is responsible for calculating seat allocations without any subjective judgment [14]. Once the code has been developed, the next step is the functional testing phase using the black-box testing method. Stress testing was also conducted by simulating database load using dummy worker data consisting of more than 500,000 rows to ensure smooth operation [6].

3 RESULTS AND DISCUSSION

3.1 System Requirements Analysis

Based on the findings of an analysis of the weaknesses in the current system, a series of functional requirements were identified that must be immediately addressed by the new software architecture. This tabulation system is required to provide a tiered platform for membership registration and verification, ranging from the labor union level to the confederation level. The system must be equipped with an automated decision-making system to interpret the passing threshold requirements and allocate representation quotas using algorithms in accordance with labor laws [24]. A separation of powers is also implemented between the government and the leadership of workers organizations.
This role-based access control is a critical non-functional requirement that must be implemented to maintain data integrity [18]. With this access configuration, each user is only permitted to access data in accordance with their respective authorizations [19]. Another critical requirement that has been identified is the systems obligation to comply with technical guidelines for conducting on-site data verification and ensuring the accuracy of the distribution of representative seats. The automation of these operations is expected to reduce the workload of government employees while increasing public confidence in the results of the allocation of representative seats [7].

3.2 Implementation of System Interfaces and Functionality

User interface design is a crucial step in building a user-friendly digital ecosystem. The authentication page is designed as a gateway that restricts public access to this tabulation system. The visual design is kept minimalist so that users are not distracted by unnecessary elements. Role-based access control begins at this step to ensure data protection from the very start of the interaction [18].

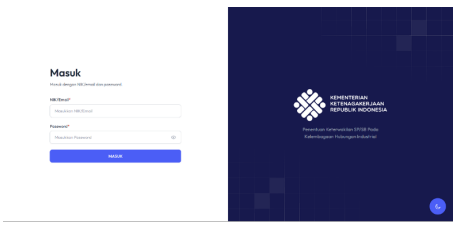

Figure 1. Login Interface

Once a user enters valid credentials, the system will immediately verify whether the information matches the data in the database. If the validation process is successful, the interface will automatically redirect the user to the dashboard page. The dashboard page serves as a statistics hub that calculates the number of verified organizations from the regency/city level up to the national level in real time.

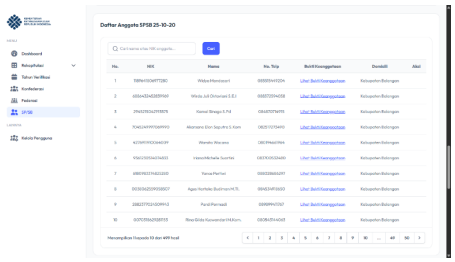

Figure 2. Index Table of Labor Union Members

The union details interface displays union data ranging from organizational information and company information to a detailed list of workers registered as union members. This page also serves as a platform for managing and verifying individual union member data, ultimately enabling the generation of a union-level summary document. In addition to member data, this page also displays the verification history of the union.

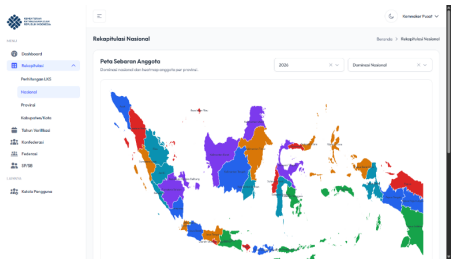

Figure 3. Map of Distribution of Confederation Members

Figure 3 presents the national distribution of confederation members through a web-based geographical visualization. The map displays membership distribution across provinces in Indonesia and provides a spatial overview of the geographical coverage of confederation membership. The visualization is integrated into the national recapitalization module, allowing users to analyze membership data at the national level. The system provides filtering options based on the verification year and national classification. In the displayed interface, the selected year is 2026 and the classification is set to "National Dominance." These filtering functions enable users to adjust the displayed information according to the required analytical parameters. The use of different colors for geographical areas facilitates the identification of provinces and improves the visual interpretation of the distribution data. The geographical visualization provides an alternative to conventional tabular presentation by representing membership data spatially. This enables users to identify the geographical distribution and concentration of members across Indonesian provinces more efficiently. The feature can therefore support monitoring, reporting, and decision-making related to the distribution of confederation membership at the national level.

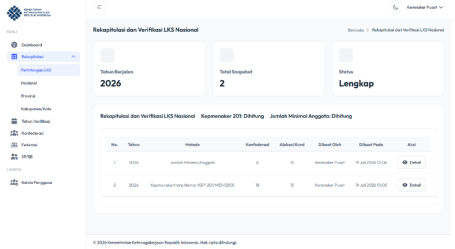

Figure 4. Tripartite Institution Calculation Interface

Figure 4 presents the tripartite institution calculation interface, which is a page for running the representative seat allocation algorithm. This page is designed to display a summary of the calculations, such as the current verification year, the total number of calculations performed, and the calculation status. This page also displays a table listing the calculations that have been performed, with a button at the top of the table that triggers the mathematical calculation. If this button is pressed when no confederation meets the requirements, the system will not perform the calculation and will immediately display an error message. The calculation will

only be performed if there is a confederation that meets the requirements in accordance with applicable laws and regulations.

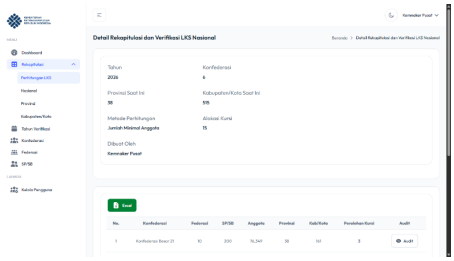

Figure 5. Calculation Results Detail

Figure 5 presents the calculation details page displaying the final results of the seat distribution process executed by the system. This page presents a summary of the results and a table listing the names of the winning confederations along with the number of representative seats they have secured in the tripartite body. In addition to displaying the final figures, this page also provides a button to revoke or cancel the calculation results. The calculation results can also be exported to Excel via this page.

Figure 6. Audit of Calculation Results for Each Confederation

Figure 6 presents the calculation audit interface specifically designed to break down the systems logical process behind seat allocation. This page displays all the details of the algorithmic workflow, starting from eligibility screening using rule-based criteria, the calculation of the fixed divisor, the number of remaining members, up to the largest remaining quota for each confederation. This feature for evaluating the calculation process provides a highly rational basis for government agencies to use in the event of future disputes over election results. The transparent presentation of this mathematical evidence is a tangible manifestation of the ministrys commitment to building a clean, honest, and trustworthy industrial relations ecosystem [16].

3.3 System Testing

The system testing phase is crucial for ensuring that all software features operate properly and are safe for use by users of various levels [18]. This functionality evaluation employs black-box testing methods, which focus on the correspondence between user input and application output without considering the code structure. This testing ensures that every button, link, and registration form on the application interface provides the correct response and rejects data formats that violate ministry regulations. The results of this black-box testing demonstrate that the software is free of functional defects and ready for deployment in a real-world government bureaucratic environment [6].

In addition to evaluating the applications functional suitability, its resilience must also be tested through operational database stress testing. This load testing was conducted using more than 500,000 rows of dummy data designed to represent the complexity of worker distribution in the field. The database was simultaneously populated with hundreds of rows of regional data, thousands of organizational records, and hundreds of thousands of records for workers as union members. This simulation also tests thousands of user records along with various other supporting data simultaneously to ensure that performance does not grind to a halt when facing a surge in access [7].

This large-scale data injection was intended to validate the servers memory capacity to handle data exchange traffic when thousands of union officials access the system simultaneously [20]. Test results show that the database architecture and the Hamilton Method algorithm continue to operate with perfect stability without experiencing screen loading delays. The computational algorithm has proven capable of completing national seat allocation calculations at a consistent speed despite having to handle various hierarchical data relationships from the company level to the national level. This capability confirms that the proposed system architecture is fully ready for implementation in future tripartite institutional decision-making processes [15].

3.4 Discussion

The primary contribution of this study lies in the successful translation of rigid legal provisions into deterministic computational logic. Unlike conventional Decision Support Systems (DSS) that rely on probabilistic or multi-criteria decision-making (MCDM) models, which are susceptible to subjective weight adjustments [9, 11], the implemented Rule-Based System operates on absolute binary logic. By strictly encoding the thresholds of Ministry of Manpower and Transmigration Regulation No. KEP-201/MEN/2001 (e.g., $P_i \geq 8$, $A_i \geq 50000$), the system eliminates human discretion in the eligibility screening phase. This deterministic approach ensures that administrative compliance is not a matter of interpretation but a verifiable computational fact [13]. Furthermore, the integration of the Hamilton Method (largest remainder method) addresses the inherent mathematical challenge of proportional representation. By systematically allocating initial seats via the floor function and redistributing remaining seats based on the highest fractional remainders, the algorithm prevents the marginalization of minority fractions. This aligns with the axiomatic principles of fair apportionment [17], ensuring that no labor organization is disproportionately disadvantaged by rounding errors, a common flaw in manual or simplified division methods [15].

The transition from decentralized, Excel-based reporting to a centralized Laravel 12 architecture directly addresses the systemic vulnerabilities identified in current bureaucratic practices. Previous studies highlight that tiered, manual data compilation is highly prone to duplication, transcription errors, and intentional manipulation to meet representation thresholds [6, 7]. The developed system mitigates these risks through two mechanisms. First, the automated validation engine instantly flags inconsistencies or duplicate entries at the point of data entry, shifting the quality control process from a post-hoc audit to a real-time preventive measure. Second, the implementation of a granular, six-tier Role-Based Access Control (RBAC) architecture ensures strict segregation of duties [18, 19]. By isolating the permissions of union administrators, regional verifiers, and central ministry officials, the system creates a robust audit trail. This architectural separation of powers is critical for maintaining data integrity and public trust, as it technically prevents unauthorized actors from altering historical membership records or calculation parameters post-verification.

The empirical validation of the system through rigorous load testing demonstrates its readiness for national-scale deployment. Simulating a database environment with over 500,000 rows of dummy worker data, alongside concurrent access from multiple hierarchical user levels, proved that the system architecture remains stable under peak load conditions. The Hamilton Method algorithm, despite requiring iterative calculations for fractional remainders across multiple confederations, executed without perceptible latency. This performance is a significant improvement over traditional spreadsheet-based methods, which typically experience severe performance degradation or file corruption when handling datasets of this magnitude. The use of Laravels optimized query builder and efficient database indexing ensures that the computational overhead of the apportionment algorithm does not compromise the user experience, thereby supporting the agile, iterative demands of modern government digital ecosystems [20].

Despite its successes, this study acknowledges certain operational limitations. Currently, the systems identity validation mechanism relies entirely on the cross-referencing of internal ministry documents and uploaded administrative files. It does not yet feature real-time API integration with the national population database (e.g., Dukcapil in Indonesia). Consequently, while the system can detect duplicate entries within its own database, it cannot definitively verify if a workers identity has been fraudulently used across different, unaffiliated unions outside the systems purview. Additionally, the rule-based eligibility criteria are currently hardcoded based on the 2001 regulation; any future amendments to labor laws would require manual updates to the source codes logical parameters, rather than dynamic, user-configurable rule engines.

The successful deployment of this hybrid algorithmic system provides a foundational framework for the digital transformation of industrial relations governance. Future research should focus on three key areas to enhance this ecosystem. First, integrating machine learning (ML) models could enable predictive analytics, mapping potential industrial conflict hotspots based on demographic shifts and union density patterns, thereby allowing the ministry to adopt proactive rather than reactive labor policies. Second, developing a secure, dynamic cloud computing infrastructure with auto-scaling capabilities will ensure that server memory and processing power can automatically adapt to the massive traffic surges expected during national verification periods. Finally, future iterations of this system must prioritize interoperability by establishing secure, encrypted API gateways with national identity systems. This would elevate the validation process from document-based matching to biometric or national-ID-based verification, virtually eradicating the possibility of phantom or duplicate union

memberships and setting a new global standard for transparent, technology-driven labor representation.

4 CONCLUSION

The design and development of a web-based system architecture for the national-level trade union membership data compilation have been successfully completed using the Laravel 12 framework. The use of this modern technology has proven highly effective in addressing the complexities of government bureaucracy from the local to the central level. The responsive interface makes it easy for users in the field to automate the reporting process, thereby speeding up completion times and minimizing data errors. This digitization has also successfully eliminated reliance on Excel, which has long been highly prone to data duplication.

The implementation of the integration of the Rule-Based System algorithm and the Hamilton Method has successfully translated each legal requirement in Ministry of Manpower and Transmigration Regulation No. KEP-201/MEN/2001 into computational instructions. The rule-based logic approach successfully screened organizations for eligibility based on geographic distribution and number of members. Furthermore, the largest-remainder method allocates proportional seats without any decimal compromises or subjective judgment. This entire calculation process has also structurally accommodated the field verification procedures mandated by Ministry of Manpower Regulation No. PER.06/MEN/IV/2005. The strategy of implementing application architecture security mechanisms through Role-Based Access Control has been successfully applied to maintain information confidentiality.

Future system development is strongly encouraged to adopt machine learning algorithms to support the mapping of potential industrial relations conflicts based on existing demographic data distributions. The addition of these analytical instruments is expected to provide deeper insights for the ministry in proactively formulating labor protection policies. Furthermore, operational evaluation reveals that worker identity validation is currently limited to cross-referencing internal ministry document files without direct synchronization with the national population database. It is highly recommended for future developers to design a dynamic cloud computing infrastructure so that memory capacity and processing engines can automatically adapt to site traffic surges.

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Author Contributions:

Zidane Fauzannajah: Conceptualization, Methodology, Software, Writing – Original Draft.
Anita Ratnasari: Formal Analysis, Resources, Supervision, Validation, Writing – Review & Editing.

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Data Availability:

The data that support the findings of this study are available from the corresponding author upon reasonable request.

AI Use Statement:

During the preparation of this manuscript, the authors used Gemini solely for language refinement and readability improvement and used ChatGPT as an assistant for programming support in Laravel and Python, including workflow suggestions, debugging assistance, and parameter optimization. All scientific content, analysis, interpretations, conclusions, and final model implementations were developed, verified, and validated by the authors. Following the use of these tools, the authors carefully reviewed and edited the manuscript and assume full responsibility for the content of the published article.

Additional Information:

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